**Health and Urban Living**
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such as wealth and status are usually highly heritable), then it is possible that runaway cultural selection has occurred in preferred levels of investment in each child (*27*), driving the quantity/quality trade-off further in the direction of offspring quality. Hence, I argue that the emergence of postindustrial life, now largely free from the fear of early mortality, seems to have generated conditions under which a runaway process of ever-escalating levels of investment in our children continues to drive fertility ever lower.

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PERSPECTIVE

# Health and Urban Living

**Christopher Dye**

**The majority of people now live in urban areas and will do so for the foreseeable future. As a force in the demographic and health transition, urbanization is associated with falling birth and death rates and with the shift in burden of illness from acute childhood infections to chronic, noncommunicable diseases of adults. Urban inhabitants enjoy better health on average than their rural counterparts, but the benefits are usually greater for the rich than for the poor, thus magnifying the differences between them. Subject to better evidence, I suggest that the main obstacles to improving urban health are not technical or even financial, but rather are related to governance and the organization of civil society.**

For the citizens of 18th century London and Paris, it was the worst of times. As far as public health was concerned, the best of times would be for future generations. By modern health standards, London in the 1700s was a slum: Between 10% and 30% of infants died before their first birthdays (*1*), and although the death rate of young children was lower in richer parts of the city, there was little variation in life expectancy across social classes. Edwin Chadwick's "sanitation revolution" gained momentum in the early 1800s and was given greater impetus by the Public Health Act of 1848, but even in 1858, the River Thames brought "the sewage of three millions of people…to seethe and ferment…in one vast open cloaca." [Winslow in (*2*)]. Conditions were no better in 19th century Paris: Relatively high food prices and poor sanitation left Parisian men more stunted than men elsewhere in France (*3*, *4*). In Europe today, about 70% of people live in urban areas. In the Europe of 1800, only 10 to 15% of people did so, partly because of the atrocious living conditions. Cholera, dysentery, measles, plague, smallpox, tuberculosis, typhus, and other infections, exacerbated by undernourishment, imposed an "urban penalty" such that deaths, mostly of children, exceeded births (Fig. 1). London, Paris, and other European cities could only grow by immigration from the countryside (*5*).

The 1848 act focused on sanitation—piping clean water to homes and safely disposing of human waste—but led on to a wider range of environmental improvements that had benefits for health, including ventilation of dwellings and streets, the preservation of green spaces, and the upgrading of road surfaces (*6*). By the start of the 20th century, urban health was typically improving faster than rural health in the industrialized world, and towns and cities grew faster than their hinterlands. As cities expanded, they started to provide a variety of indirect benefits to health: large markets with a steady and diverse food supply, economies of scale with low transportation costs, organized public services, and a critical mass of educated people that was needed

**Fig. 1.** An illustration of the beginning of a cholera epidemic in Paris, April 1832, by Jules Pelcoq, from an 1866 edition of *Histoire Populaire de la France*, published by Hachette. [Stefano Bianchetti/Corbis]

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to establish centers of enterprise, learning, and innovation.

Today, more than half the world's population—about 3.3 billion people—lives in urban areas (*7*), including roughly 50,000 settlements of at least 50,000 people (*8*, *9*). By 2015, and for the foreseeable future beyond, population growth will be mainly urban, mainly in the 500 or so cities that have 1 million to 10 million inhabitants, and mainly in poorer countries. Although three-quarters of the people who earn less than a dollar a day still live in rural areas, the proportion and number of poor people living in urban areas are rising (*10*). About one in three urban inhabitants—roughly one billion people—now live in slums, but the proportions are much higher than this average in sub-Saharan Africa and South Asia (*7*).

Some of these contemporary statistics, set against the historical backdrop of urbanization in Europe, give reason for thinking that life in built-up areas could be worse than in the surrounding countryside. The risks to health are obvious where urban water supplies are polluted, coastal sites are susceptible to flooding, crowding promotes the spread of infectious diseases, electricity supplies are intermittent, health services are inaccessible, life without family and social support is desolate, and roads and recreation areas are dangerous. Yet the sanitation revolution, and its aftermath, makes it clear that urban health has the potential to be far better than rural health. Although the nascent literature on urban living gives examples of both positive and negative effects, the general features of urban health are only just being described and explained. Here, I describe five characteristics of urban health that underpin the debate about how to foster healthy urban living in the future.

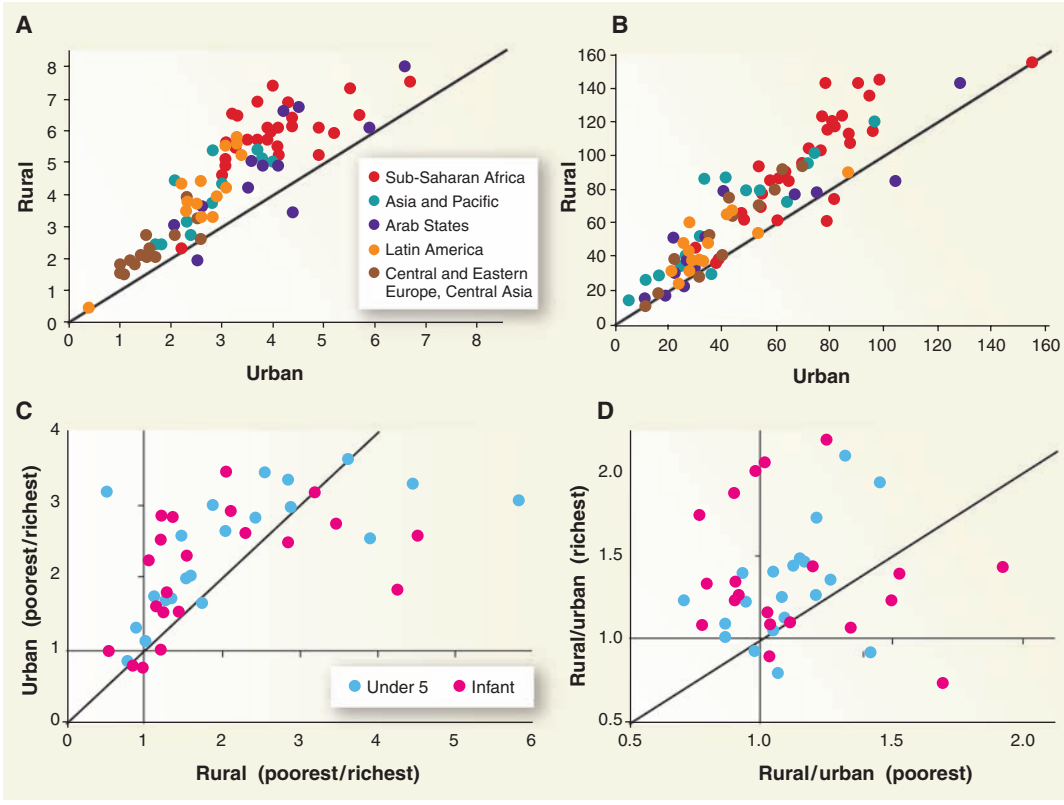


**Fig. 2.** (**A**) Fertility rates (births per woman 15 to 49 years) and (**B**) infant mortality rates (<1 year, per 1000 births) are typically higher in rural than urban areas (i.e., above the diagonals that mark the points where rates are the same in urban and rural areas). Regions in (B) are color-coded as in (A). (**C** and **D**) Child mortality ratios. Inequality in infant (red) and under 5 (blue) mortality tends to be greater in urban than rural areas, as judged from mortality ratios in (C) poorest 20%/richest 20% of families and (D) rural/urban areas (ratios mostly above diagonal). (D) Although urban living is especially beneficial for the rich, the poor generally benefit, too (ratios mostly >1). Poverty and wealth are determined from a household asset score in Demographic and Health Surveys (*20*). Data in (A) and (B) are from 94 and 90 countries, respectively (*13*), data in (C) are from 22 surveys in 18 countries, and data in (D) are from 22 surveys in 17 countries (*21*).

First, within countries, health is generally better on average in urban than in rural areas (*8*, *10*, *11*). By contrast with Europe up to the 19th century, births exceed deaths in most, if not all, urban agglomerations today. Consequently, many urban centers now show endogenous growth, in addition to growth by immigration from the countryside. Furthermore, although the number of slum-dwellers is growing in most parts of the world, the number of richer people is growing faster, mainly as a result of the wide range of economic opportunities that cities provide. Between 1990 and 2001, the slum population of Indonesia grew by 1.4% annually, but the whole urban population was rising at 4.4%, doubling in 16 years (*12*). In general, slum dwellers are a diminishing fraction of urban populations, and this is one reason that urban health is, on average, getting better.

The comparative health advantage of urban living is also revealed in lower fertility (Fig. 2A) and infant mortality rates (Fig. 2B), which have numerous interlinked determinants, including improved sanitation and nutrition, and easier access to contraception and health care (*13*, *14*). The strong correlations in Fig. 2, A and B, make a second important point: Although fertility and mortality rates tend to be lower in cities, the rates in urban and rural areas remain tied. In comparisons among countries, low urban mortality is associated with low rural mortality. Cities do not exist in isolation; they are part of the "national metabolism." Studies on the link between urban and rural poverty have suggested that the growing wealth of cities brings direct benefits to people living in rural areas (*10*).

Third, while urbanization appears to be a force for better health (*10*), the force does not operate in the same way everywhere. In comparisons among countries, 40% of the variation in child mortality is explained by the proportion of the population living in urban areas, but most of this (34%) is due to interregional differences (Fig. 3) (*15*, *16*). The mortality rate of children under 5 years in sub-Saharan Africa is about 10 times as high as it is in the established market economies, but in neither region is child mortality much affected by the level of urbanization. Clearly, health can and does tend to improve with urbanization, but the scale of the benefits is conditional on other factors, such as the effectiveness of public services and the opportunity for private enterprise.

Fourth, the health benefits of urbanization are not uniform (*17*–*19*). Urbanization, poverty reduction, and improvements in health are linked through economic growth (*10*), but economic growth is also associated with greater health inequalities within countries, as measured in

terms of the variation in child mortality, stunting, underweight, and life expectancy, and the association holds within the richest and the poorest nations alike (*19*).

Urban living is one factor associated with these growing disparities. Demographic and Health Surveys (DHS) (*20*, *21*), which provide unusually reliable data on urban health, reveal that the children of both rich and poor families gain from urban living, but the rich gain more. The ratio of child mortalities (infant and under 5 years) in the poorest 20% of families to the richest 20% is typically higher in urban than rural areas (Fig. 2C). To reinforce the point, rural/urban mortality ratios are mostly greater than 1 (upper right quadrant), but higher for the richest than for the poorest families (above diagonal, Fig. 2D) (*21*). Ratios less than 1 sometimes arise when the children of the urban poor (e.g., slum dwellers) suffer high mortality rates compared with the rural population (*22*, *23*). However, while urbanization magnifies the disparities in child survival in many countries, it does not do so everywhere; the exceptions revealed in DHS include Bolivia, the Dominican Republic, Egypt, Indonesia, Morocco, and Peru.

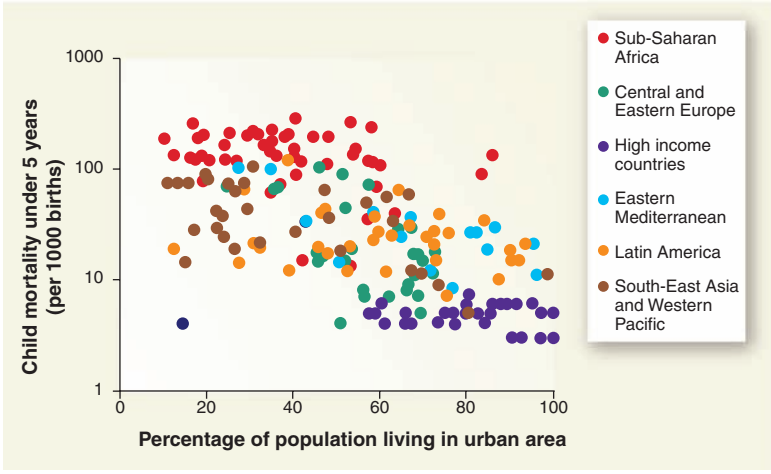


**Fig. 3.** Mortality rates of children under 5 years are lower in countries that are more urbanized, but mainly through differences between rather than within regions. Data are for 2005 (*15*, *16*).

Fifth, we may assume that the health of adults, as for children, tends to be better in urban areas. However, no investigation has yet shown that the health benefits of urban living generally outweigh the health risks. City dwellers are comparatively wealthy and lead more sedentary lives with easier access to low-cost, low-fiber, high-energy, high-fat food. The proportion of adults (and children) who are overweight is rising in both rural and urban settings, but it is rising faster in cities (*24*), with implications for the incidence of diabetes, heart disease, certain cancers, and stroke. Nevertheless, where a higher proportion of people is overnourished, a lower proportion is undernourished (*24*), reducing stunting, wasting, and other conditions due to micro- and macronutrient deficiencies. In some countries, such as China, indoor air pollution is worse in certain rural than urban areas and has a bigger impact on chronic obstructive pulmonary disease (*25*). The poorer inhabitants of cities, though, are often exposed both to indoor and outdoor air pollution, and the effects of air pollutants on lung diseases in cities have not been systematically measured. Traffic accidents, mostly in the rapidly growing, congested cities of developing countries, now kill more than a million children and adults each year, and the number of casualties worldwide is bound to rise (*26*). However, richer countries have shown how measures to improve road safety can be rewarded by a steady fall in casualties. Communicable diseases pose both greater and lesser risks to adults in towns and cities, depending on the life cycles of the pathogens involved. The lower incidence of malaria in urban areas (*27*) may, depending on the setting, be offset by the greater incidence of HIV infection (*28*) or tuberculosis (*29*). Whether the transmission of Chagas disease and dengue is augmented or diminished in urban areas depends on details such as the quality of house construction (resting sites for triatomine insect vectors in cracked walls) and the distribution of standing water (habitat for larval mosquitoes).

In sum, urbanization is a force in the global demographic transition from high to low birth rates and short to long life spans, and in the health and nutritional transitions that are shifting the burden of illness from acute childhood infections to chronic and mostly noncommunicable diseases of adults. Children have a higher chance of surviving to adulthood in urban areas, but the potential benefits of urbanization have been unevenly exploited around the world. The urban environment favors many of its inhabitants, but especially the rich and not always the poor. Adults, too, probably enjoy better health in cities, but hard facts are hard to find.

Although rural-urban comparisons provide a convenient framework for analysis, the urban health goal is not simply to be better on average than rural areas. Nor is it satisfactory to trade one medical condition against another in summary statistics on life expectancy. The ambition must be to attain good health for all absolutely. In this context, the Millennium Development Goal of achieving "a significant improvement in the lives of at least 100 million slum dwellers" by 2020, a mere 10% of current numbers, is decidedly modest (*30*). In deciding, based on the available evidence, how to reach and exceed these goals, some provocative comparisons can be made between cities. For instance, why are infant mortality rates in Curitiba, Brazil (~10/1000 births), so much less than in Nairobi, Kenya (~40/1000 births on average and over 90/1000 births in slums) (*22*)? Among the many differences between these two cities, which are crucial?

Many of the prescriptions for better urban health are in fact self-evident and are often inexpensive: healthy housing, primary health care, communicable disease control through sanitation and vaccination, safe roads, and targeted assistance to women. They are also not specific to urban areas. The tough problem is that technical solutions need a framework in which they can be executed. Hence, the call for "healthy governance," regulated land ownership, probity in financial investment, social cohesion, the empowerment of civil society, and foresight in planning the physical environment (*7*, *11*, *30*). The right structure is hard to create because there are no recipes for social cohesion and good governance. Yet there is an imperative to succeed: If cities are the "defining artifacts of civilisation" (*31*), a nation may now be judged by the health of its urban majority.

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PERSPECTIVE

# The Size, Scale, and Shape of Cities

**Michael Batty**

**Despite a century of effort, our understanding of how cities evolve is still woefully inadequate. Recent research, however, suggests that cities are complex systems that mainly grow from the bottom up, their size and shape following well-defined scaling laws that result from intense competition for space. An integrated theory of how cities evolve, linking urban economics and transportation behavior to developments in network science, allometric growth, and fractal geometry, is being slowly developed. This science provides new insights into the resource limits facing cities in terms of the meaning of density, compactness, and sprawl, and related questions of sustainability. It has the potential to enrich current approaches to city planning and replace traditional top-down strategies with realistic city plans that benefit all city dwellers.**

Throughout the 19th century, social commentators universally damned the growth of cities, the chorus rising to a crescendo in the writings of William Morris, who spoke of "the hell of London and Manchester" and "the wretched suburbs that sprawl all round our fairest and most ancient cities" (*1*). These sentiments have dominated our approach to cities and their planning to this day: Cities are still seen as manifesting a disorder and chaos requiring control through the imposition of idealized geometric plans. There have been few dissenting voices, an exception being Jane Jacobs (*2*), who argued half a century ago that far from being homogeneous and soulless, cities are essential crucibles for innovation, tolerance, diversity, novelty, surprise, and most of all, for economic prosperity.

In the past 25 years, our understanding of cities has slowly begun to reflect Jacobs's message. Cities are no longer regarded as being disordered systems. Beneath the apparent chaos and diversity of physical form, there is strong order and a pattern that emerges from the myriad of decisions and processes required for a city to develop and expand physically (*3*). Cities are the example par excellence of complex systems: emergent, far from equilibrium, requiring enormous energies to maintain themselves, displaying patterns of inequality spawned through agglomeration and intense competition for space, and saturated flow systems that use capacity in what appear to be barely sustainable but paradoxically resilient networks.

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## The Size and Scale of Cities

Urban complexity has its basis in the regular ordering of size and shape across many spatial scales (*4*). Cities grow larger to facilitate a division of labor that generates scale economies (*5*), and it is a simple consequence of competition and limits on resources that there are far fewer large cities than small. However, the self-similarity observed across many spatial levels implies that the processes that drive agglomeration and clustering in small cities are similar to those in large cities; indeed in cities of any size.

A lot of the work on scaling has taken cities, firm sizes, and incomes as key exemplars. In the 1930s, Christaller first showed that market areas or hinterlands around cities scaled across a geometric hierarchy in terms of their population size (*6*). Gibrat (*7*) argued that such scaling could be approximated from log-normal distributions, which emerge when objects (cities and firms) grow randomly but proportionately, whereas Simon's simple birth and death models (*8*) have been widely applied to demonstrate the same logic. Recently Gabaix, Solomon, and others (*9*, *10*) have shown that such growth generates scaling in the steady state, which is consistent with various economic models that explain how systems grow through agglomeration. A consequence of all this is that many physical (geometric) and functional (economic) explanations are converging (*11*, *12*). The volume of work is now so extensive that a wide variety of size distributions are now known to show scaling (*13*). Examples for city populations over 1 million, for cities in the United States with over 100,000 people, and for the 200 tallest buildings in the world are shown in Fig. 1A.

There are still many puzzles associated with such scaling. Gibrat's law assumes that not only are growth rates random but so is their variance, yet there is now considerable evidence that such rates and their variances scale with size (*14*, *15*). Despite agglomeration effects that relate to size, there is a strong suspicion that the best places to locate new growth are in smaller rather than larger cities, reflecting the tradeoff between economies of scale and congestion, which both increase as cities get bigger. The implications are controversial. The age-old question of what the "optimal" size for a city is is as open as it has ever been.

## Interactions, Networks, and Densities

Where the focus is on interactions between cities in terms of trade or migration, and within